

Appendix B from K. A. Schmidt et al., “Information-Mediated Allee Effects in Breeding Habitat Selection” (Am. Nat., vol. 186, no. 6, p. E162)

Effect of Changes in the Relative Proportion (i.e., Variance) of Habitat Availability

In the main text, we noted that the qualitative outcomes of our model (e.g., weak or strong Allee effects) depended not only on a population’s capacity for information (i.e., w_0 - a plane; fig. 2) but also on habitat composition. Here we illustrate this effect graphically by comparing the effects of informed habitat selection on per capita population growth when (1) bad sites (proportion p_B) and good sites ($1 - p_B$) are equally abundant ($p_B = 0.5$; fig. B1A) and (2) bad sites are proportionately more abundant ($p_B = 0.60$; fig. B1B, B1C).

In response to increasing the relative abundance of bad sites (reciprocal effects occur with decreasing p_B), mean habitat quality declines, and, concomitantly, there is an increase in the likelihood that a bad site will be drawn from the pool of available sites. The latter affects the mean quality of occupied habitat, which is influenced by both information and population density. In contrast, mean habitat quality is invariant and, hence, independent of information and unaffected by population density. Therefore, to isolate the change in the per capita population growth rate due to changes in habitat composition, we must hold mean habitat quality (i.e., reproductive output) constant (C): $R_G(1 - p_B) + R_B p_B = C$. This is accomplished by increasing either R_G or R_B (see fig. B1B, B1C) to offset the effect of increasing p_B .

We graphically illustrate the effect of changing habitat composition per se on the generation of Allee effects without the confounding influence of altering mean habitat quality in figure B1. Under random site selection, the scenarios are identical (fig. B1, red curve). This is not true when habitat selection is informed. With informed habitat selection, per capita population growth rates vary with habitat composition, p_B and whether R_G or R_B was increased to hold mean site quality constant (fig. B1B, B1C).

To understand how these effects arise, we must consider the level of uncertainty in habitat quality based on random choice and the added fitness benefit from a correct choice. Koops (2004) defined the value of correct information (VI) as the difference between being informed (I) and uninformed (U): $VI = I - U$; in our model, $VI = R_G - C$. All three scenarios (fig. B1) have the same value for C, whereas the value of being informed, R_G , is greater in figure B1C ($VI = 0.9375$) than in figure B1A and B1B ($VI = 0.625$). All else being equal, population growth rates will be higher when VI increases, the exception occurring when no information is available ($w_0 = 1$, $a = 0$; red line). Hence, when good habitat is converted to bad, it is better to increase R_G than R_B . However, as p_G declines further, one must increase R_G at an accelerating rate (K. A. Schmidt, J. Johansson, M. G. Betts, unpublished data) to maintain mean quality, which may not be realistic or cost effective.

The relative level of environmental uncertainty also differs between panels: the scenario in figure B1A ($p_G = p_B$) has greater uncertainty than the scenarios in figures B1B and B1C ($p_G \neq p_B$). Here we compare B1A and B1B, which have the same VI based on Koops’s definition (see above). Donaldson-Matasci et al. (2010) show that the fitness value of information from a predictive cue (to a given environmental state) is intimately related to the amount of information about the environment that the cue carries (i.e., mutual information; details in Donaldson-Matasci et al. 2010). The latter is reduced when total uncertainty (i.e., entropy) in the environment, H' (better known to ecologists as the Shannon diversity index), increases. Specifically, H' is maximized when environmental states are equally probable ($p_G = p_B$), as in figure B1A. Therefore, the environmental composition places bounds on the value of information. Deviating from maximum uncertainty reduces the fitness value of information and, hence, population growth rate. This is seen when comparing panel figure B1A ($p_B = p_G$) and figure B1B ($p_B > p_G$). The same holds true when comparing $p_B = p_G$ to $p_B < p_G$ (K. A. Schmidt, J. Johansson, M. G. Betts, unpublished data).

Otherwise, it remains difficult to reconcile our heuristic approach with those of Koops (2004) and Donaldson-Matasci et al. (2010) since the targets of our investigations are unique: the above authors emphasize the amount of uncertainty and the value of information from a cue or signal, whereas we emphasize the population consequences. Nonetheless, together, these different approaches demonstrate that the frequency distribution of site quality plays an important role in determining population growth rates when habitat selection is informed. In addition, this result is general and suggests

unforeseen opportunities to manage information for conservation value. For instance, retaining a sufficient proportion of good habitat can produce benefits that exist independently of mean habitat quality.

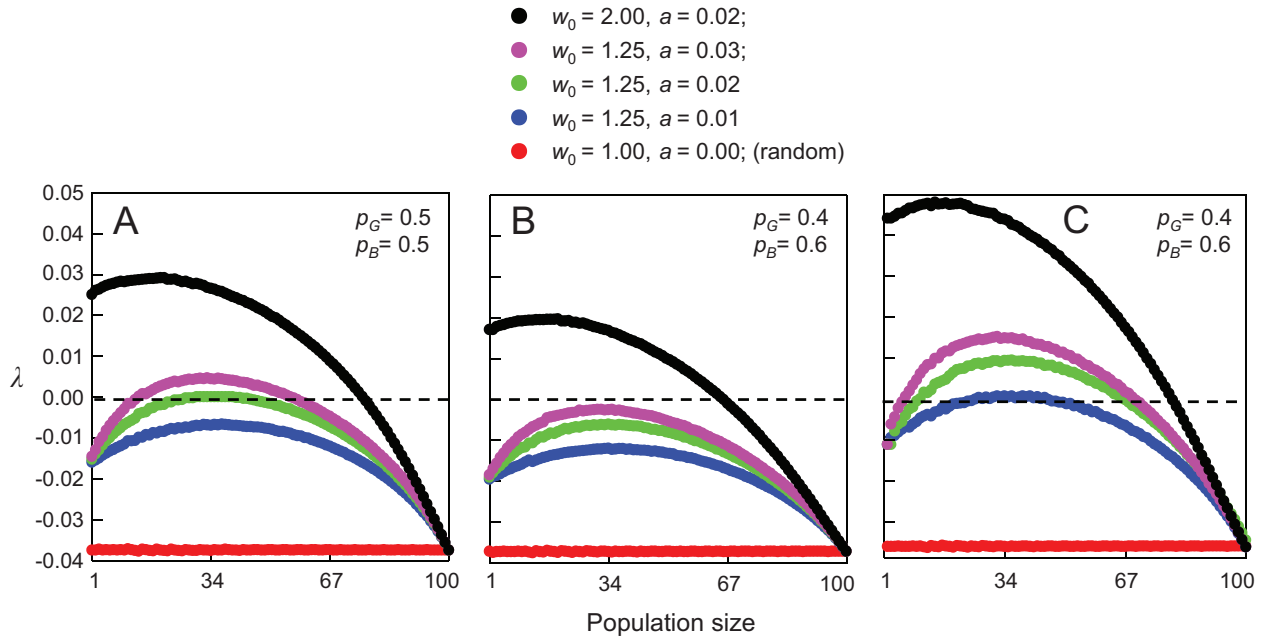


Figure B1: Qualitative and quantitative differences in per capita population growth rates (λ) due to an increase in proportion of bad sites, p_B , in panels *B* and *C*. Mean site quality is constant (~ 0.963) in all panels. To compensate for an increase in p_B , either R_B was increased (from 0.25 to 0.458; *B*) or R_G was increased (from 1.5 to 1.813; *C*). Fixed parameters in all panels are as follows: $S_A = 0.70$, $S_j = 0.3$, $T = 100$. See main text for definition of terms.